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PATENT APPLICATION

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Transmitted herewith for filing is the patent application of Inventor(s):

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**For: METHOD AND SYSTEM FOR CONTROLLING VEHICLE DECELERATION IN AN ADAPTIVE SPEED CONTROL SYSTEM BASED ON VEHICLE SPEED**

Enclosed are:

- 2 sheet(s) of drawings  
 Assignment and Cover Sheet  
 Information Disclosure Statement, PTO Form 1449, and Copies of Citations  
 A certified copy of

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199-1506

METHOD AND SYSTEM FOR CONTROLLING  
VEHICLE DECELERATION IN AN ADAPTIVE  
SPEED CONTROL SYSTEM BASED ON VEHICLE SPEED

Technical Field

5         This invention relates to a method and system for controlling a maximum allowed vehicle deceleration in an adaptive speed control system based on vehicle speed.

Background Art

10         Adaptive Cruise (*i.e.*, speed) Control (ACC) systems operate much like conventional Cruise Control systems, with the added capability of being able to sense in-path vehicles and to slow the ACC equipped vehicle in response. An ACC equipped vehicle thereby 15 allows its operator to automatically control the vehicle speed, as with conventional Cruise Control, without the necessity of having to deactivate and reactivate control whenever slower traffic is encountered.

20         As is well known in the art, existing ACC methods and systems use a forward looking range sensor such as radar to sense an in-path vehicle (which may also be referred to as a sensed target or primary target). Based on the radar sensor information, such

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ACC methods and systems then determine the range and relative velocity (or range rate) of the sensed in-path vehicle. Using the range and range rate, the speed of the ACC equipped vehicle is controlled to 5 maintain a selected following interval between the ACC equipped vehicle and the sensed in-path vehicle. The speed of the ACC equipped vehicle is typically controlled by automatic control of the vehicle throttle actuator. In more advanced ACC methods and 10 systems, vehicle speed may also be controlled by automatic control of vehicle brake actuators. Such ACC methods and systems have the ability to apply a moderate degree of braking to the vehicle to achieve further vehicle deceleration (*i.e.*, in addition to 15 vehicle deceleration achieved via throttle control) in response to an in-path vehicle.

Thus, in maintaining the selected following interval, existing ACC methods and systems may decelerate the ACC equipped vehicle. In such 20 situations, the deceleration the ACC equipped vehicle may take any value up to a maximum allowed deceleration, which is typically 0.3 g. In existing ACC methods and systems, however, such a maximum allowed deceleration is constant, regardless of 25 vehicle speed. As a result, at higher vehicle speeds, deceleration of the ACC equipped vehicle at the maximum allowed deceleration may be perceived as uncomfortable by the vehicle operator. Conversely, at lower vehicle speeds, deceleration of the ACC equipped

vehicle at that same maximum allowed deceleration may be perceived as insufficient by the vehicle operator.

As a result, there exists a need in an ACC system for a method and system for controlling the maximum allowed vehicle deceleration based on the vehicle speed. More specifically, such a method and system would set the maximum allowed vehicle deceleration as a function of the vehicle speed, increasing the maximum allowed vehicle deceleration at lower vehicle speeds and decreasing the maximum allowed vehicle deceleration at higher vehicle speeds. Such a method and system would thereby provide the ACC equipped vehicle with a more comfortable response for the vehicle operator.

15    Disclosure Of Invention

Accordingly, it is a principal object of the present invention to provide, in a vehicle equipped with an adaptive speed control system, a method and system for controlling the maximum allowed vehicle deceleration based on the speed of the vehicle.

According to the present invention, then, in an adaptive speed control system for a vehicle, a method is provided for controlling vehicle deceleration. The method comprises determining a speed of the vehicle, and setting a maximum allowed vehicle deceleration based on the vehicle speed determined.

Similarly, in an adaptive speed control system for a vehicle, a system is also provided for controlling vehicle deceleration. The system comprises a receiver capable of receiving an input signal indicative of the speed of the vehicle, and a controller capable of setting a maximum allowed vehicle deceleration based on the vehicle speed.

These and other objects, features and advantages of the present invention will be readily apparent upon consideration of the following detailed description of the invention in conjunction with the accompanying drawings.

#### Brief Description Of Drawings

Figure 1 is a simplified block diagram of an adaptive cruise control system, including the system of the present invention;

Figure 2 is a graph of maximum allowed vehicle deceleration over a range of vehicle speeds according to the prior art in a vehicle equipped with an adaptive speed control system;

Figure 3 is a graph of maximum allowed vehicle deceleration as a function of vehicle speed according to the method and system of the present invention in a vehicle equipped with an adaptive speed control system; and

Figure 4 is a flowchart of the method of the present invention.

Best Mode For Carrying Out The Invention

Referring to Figures 1-4, the preferred embodiment of the method and system of the present invention will now be described. In that regard,  
5 Figure 1 illustrates a simplified block diagram of an Adaptive Cruise Control (ACC) system, including the system of the present invention, denoted generally by reference numeral 10.

In general, as is well known to those of ordinary skill in the art, ACC system (10) is a closed loop control system intended to respond to potential targets in front of and in the same lane of traffic as the vehicle equipped with the ACC system (10). The goal of ACC system (10) is to partially automate the  
10 continuous longitudinal control of the vehicle, thereby providing the vehicle operator with improved comfort and convenience. In that regard, ACC system (10) may operate in either a normal or a following mode. In normal mode operation, ACC system (10)  
15 controls the speed of the ACC equipped vehicle to the speed set by the vehicle operator as the control speed. In following mode operation, ACC system (10) controls the speed of the ACC equipped vehicle to the speed of a sensed in-path vehicle (which may be referred to as a sensed target or a primary target).  
20  
25

More specifically, as seen in Figure 1, the ACC system (10) includes a vehicle controller (12) provided in communication with a range sensor (14), a

speed sensor (16), a yaw rate sensor (18), a user interface (20), a throttle actuator (22), and a brake actuator (24). As previously described, the system (10) extends the function of conventional speed control systems. In that regard, based on range and relative velocity information obtained and/or derived from forward looking range sensor (14) and speed sensor (16), vehicle controller (12) uses throttle and brake actuators (22, 24) to control the speed of the ACC equipped vehicle in order to maintain a selected following interval (in seconds) between the ACC equipped vehicle and a sensed target (i.e., a lead vehicle) in the forward path of travel of the ACC equipped vehicle.

The following interval between the ACC equipped vehicle and the sensed target is initially set at a default value (typically two seconds) upon activation of the system (10), but may be modified by the vehicle operator to a number of other selectable values (typically a value greater than or equal to one second, but less than or equal to two seconds) via user interface (20). The default following interval is typically the maximum following interval allowed, and modification of the following interval by the vehicle operator is permitted between that maximum and a defined minimum following interval (typically one second). The following interval is referred to as headway, and is defined as the range to the sensed target (in meters), divided by the speed of the ACC

equipped vehicle (in meters per second). User interface (20) is also used by the vehicle operator to set the desired vehicle control speed.

As previously noted, ACC systems and methods  
5 are well known in the art. As a result, a detailed  
description of the general operation of ACC system  
(10), including such functions as acquisition,  
discrimination, differentiation, selection and  
tracking of targets, range and relative velocity  
10 (range rate) determinations, sensor operations, and  
throttle and brake control is unnecessary and, for the  
sake of brevity, is not set forth herein. In  
connection with the method and system of the present  
invention, such functions of ACC system (10) may be  
15 undertaken in any fashion known to those of ordinary  
skill.

As also previously noted, while maintaining  
the selected following interval, existing ACC methods  
and systems may decelerate the ACC equipped vehicle.  
20 In such situations, the deceleration the ACC equipped  
vehicle may take any value up to a maximum allowed  
deceleration, which is typically 0.3 g. In existing  
ACC methods and systems, however, such a maximum  
allowed deceleration is constant, regardless of  
25 vehicle speed. In that regard, Figure 2 is a  
graphical representation of an example of a maximum  
allowed vehicle deceleration according to the prior  
art in an ACC equipped vehicle. As seen therein, the  
maximum allowed vehicle deceleration is 0.3 g, and

remains constant over the entire range of possible vehicle speeds.

In that regard, the same constant braking force on a vehicle, in terms of a vehicle deceleration, is perceived by a vehicle operator as much higher, and therefore less comfortable, at higher vehicle speeds than at lower vehicle speeds. Thus, at higher vehicle speeds, deceleration of the ACC equipped vehicle at the maximum allowed deceleration may be perceived as uncomfortable by the vehicle operator. Conversely, at lower vehicle speeds, deceleration of the ACC equipped vehicle at that same maximum allowed deceleration may be perceived as insufficient by the vehicle operator.

In contrast, the present invention provides, in the ACC system (10) of Figure 1, a method and system for controlling the maximum allowed vehicle deceleration based on the vehicle speed. More specifically, the present invention sets the maximum allowed vehicle deceleration as a function of the vehicle speed, increasing the maximum allowed vehicle deceleration at lower vehicle speeds and decreasing the maximum allowed vehicle deceleration at higher vehicle speeds. In such a fashion, the present invention provides the ACC equipped vehicle with a more comfortable response for the vehicle operator.

In that regard, Figure 3 is a graphical representation of a preferred example of a maximum allowed vehicle deceleration according to the present

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invention in an ACC equipped vehicle. As seen therein, at low vehicle speeds, such as approximately 10 miles per hour or less, the maximum allowed vehicle deceleration is approximately 0.3 g, the maximum 5 vehicle deceleration typically employed in prior art ACC methods and systems. However, as the speed of the ACC equipped vehicle increase, the maximum vehicle deceleration allowed decreases to a minimum of approximately 0.2 g at higher vehicle speeds such as 10 approximately 100 miles per hour or greater. As those of ordinary skill will appreciate, the preferred maximum allowed vehicle deceleration shown in Figure 3 is an exponential function of the vehicle speed. More specifically, the preferred maximum allowed vehicle 15 deceleration according to the present invention may be defined by the equation:

$$(1) \quad \text{MAXDECCEL} = 0.2 + 160 / (\text{VEHSPD} + 40)^2,$$

where MAXDECCEL is the maximum allowed vehicle deceleration, and VEHSPD is the vehicle speed.

20 Referring again to Figure 1, the system of the present invention is preferably included in vehicle controller (12). In that regard, vehicle controller (12) includes a receiver (not shown) capable of receiving an input signal from speed sensor 25 (16) indicative of the speed of the ACC equipped vehicle. Vehicle controller (12) also includes a controller (not shown) capable of setting a maximum

allowed vehicle deceleration based on the vehicle speed. It should be noted here that the controller (as well as vehicle controller (12) of ACC system (10)) may take the form of an appropriately programmed microprocessor, or any equivalent thereof.

In that regard, to set a maximum allowed vehicle deceleration based on the vehicle speed, the controller is capable of adjusting the maximum allowed vehicle deceleration in an inverse relationship to the vehicle speed. More specifically, the controller is capable of decreasing the maximum allowed vehicle deceleration as the vehicle speed increases, and of increasing the maximum allowed vehicle deceleration as the vehicle speed decreases.

According to the system of the present invention, the maximum allowed vehicle deceleration is preferably capable of varying continuously. As previously noted, the maximum allowed vehicle deceleration is preferably defined as an exponential function of the vehicle speed, as in equation (1) above. However, the maximum allowed vehicle deceleration may be defined as any of a number of other inverse functions of the vehicle speed, such as linear, where the maximum allowed vehicle speed generally decreases as the vehicle speed generally increases, and generally increases as the vehicle speed generally decreases. Regardless of the function employed, the maximum allowed vehicle deceleration preferably varies between approximately 0.2 g at lower

vehicle speeds and approximately 0.3 g at higher vehicle speeds.

Referring now to Figure 4, a flowchart of the method of the present invention is shown, denoted generally by reference numeral 40. As seen therein, the method (40) of the present invention comprises determining (42) a speed of the vehicle, and setting (44) a maximum allowed vehicle deceleration based on the vehicle speed determined. In that regard, as described above in connection with the system of the present invention, setting (44) a maximum allowed vehicle deceleration based on the vehicle speed includes adjusting the maximum allowed vehicle deceleration in an inverse relationship to the vehicle speed, including decreasing the maximum allowed vehicle deceleration as the vehicle speed increases, and increasing the maximum allowed vehicle deceleration as the vehicle speed decreases.

As with the system of the present invention, according to the method of the present invention, the maximum allowed vehicle deceleration is preferably capable of varying continuously. Once again, the maximum allowed vehicle deceleration is preferably defined as an exponential function of the vehicle speed, as in equation (1) above, although any of a number of other inverse functions of the vehicle speed may be used where the maximum allowed vehicle speed generally decreases as the vehicle speed generally increases, and generally increases as the vehicle

speed generally decreases. As previously noted, regardless of the function employed, the maximum allowed vehicle deceleration preferably varies between approximately 0.2 g at lower vehicle speeds and approximately 0.3 g at higher vehicle speeds.

From the foregoing description, it can be seen that the present invention provides, in an ACC system, a method and system for controlling the maximum allowed vehicle deceleration based on the vehicle speed. More specifically, the present invention sets the maximum allowed vehicle deceleration as a function of the vehicle speed, increasing the maximum allowed vehicle deceleration at lower vehicle speeds and decreasing the maximum allowed vehicle deceleration at higher vehicle speeds. In such a fashion, the present invention provides the ACC equipped vehicle with a more comfortable response for the vehicle operator.

While various embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

What Is Claimed Is:

1           1. In an adaptive speed control system for  
2 a vehicle, a method for controlling vehicle  
3 deceleration, the method comprising:

4                 determining a speed of the vehicle; and  
5                 setting a maximum allowed vehicle  
6 deceleration based on the vehicle speed determined.

1           2. The method of claim 1 wherein setting a  
2 maximum allowed vehicle deceleration based on the  
3 vehicle speed includes adjusting the maximum allowed  
4 vehicle deceleration in an inverse relationship to the  
5 vehicle speed.

1           3. The method of claim 2 wherein adjusting  
2 the maximum allowed vehicle deceleration comprises  
3 decreasing the maximum allowed vehicle deceleration as  
4 the vehicle speed increases.

1           4. The method of claim 2 wherein adjusting  
2 the maximum allowed vehicle deceleration comprises  
3 increasing the maximum allowed vehicle deceleration as  
4 the vehicle speed decreases.

1           5. The method of claim 2 wherein the  
2 maximum allowed vehicle deceleration is capable of  
3 varying continuously.

1                 6. The method of claim 5 wherein the  
2 maximum allowed vehicle deceleration is capable of  
3 varying in a range between about 0.2 g and about  
4 0.3 g.

1                 7. The method of claim 2 wherein the  
2 maximum allowed vehicle deceleration is an exponential  
3 function of the vehicle speed.

1                 8. The method of claim 7 wherein the  
2 maximum allowed vehicle deceleration is defined by the  
3 equation:

4                           $\text{MAXDECEL} = 0.2 + 160 / (\text{VEHSPD} + 40)^2$ ,

5 where MAXDECEL is the maximum allowed vehicle  
6 deceleration, and VEHSPD is the vehicle speed.

1                 9. In an adaptive speed control system for  
2 a vehicle, a system for controlling vehicle  
3 deceleration, the system comprising:

4                          a receiver capable of receiving an input  
5 signal indicative of a speed of the vehicle; and  
6                          a controller capable of setting a maximum  
7 allowed vehicle deceleration based on the vehicle  
8 speed.

1                 10. The system of claim 9 wherein, to set a  
2 maximum allowed vehicle deceleration based on the

3       vehicle speed, the controller is capable of adjusting  
4       the maximum allowed vehicle deceleration in an inverse  
5       relationship to the vehicle speed.

1                 11. The system of claim 10 wherein, to  
2       adjust the maximum allowed vehicle deceleration, the  
3       controller is capable of decreasing the maximum  
4       allowed vehicle deceleration as the vehicle speed  
5       increases.

1                 12. The system of claim 10 wherein, to  
2       adjust the maximum allowed vehicle deceleration, the  
3       controller is capable of increasing the maximum  
4       allowed vehicle deceleration as the vehicle speed  
5       decreases.

1                 13. The system of claim 10 wherein the  
2       maximum allowed vehicle deceleration is capable of  
3       varying continuously.

1                 14. The system of claim 13 wherein the  
2       maximum allowed vehicle deceleration is capable of  
3       varying in a range between about 0.2 g and about  
4       0.3 g.

1                 15. The system of claim 10 wherein the  
2       maximum allowed vehicle deceleration is an exponential  
3       function of the vehicle speed.

1               16. The system of claim 15 wherein the  
2 maximum allowed vehicle deceleration is defined by the  
3 equation:

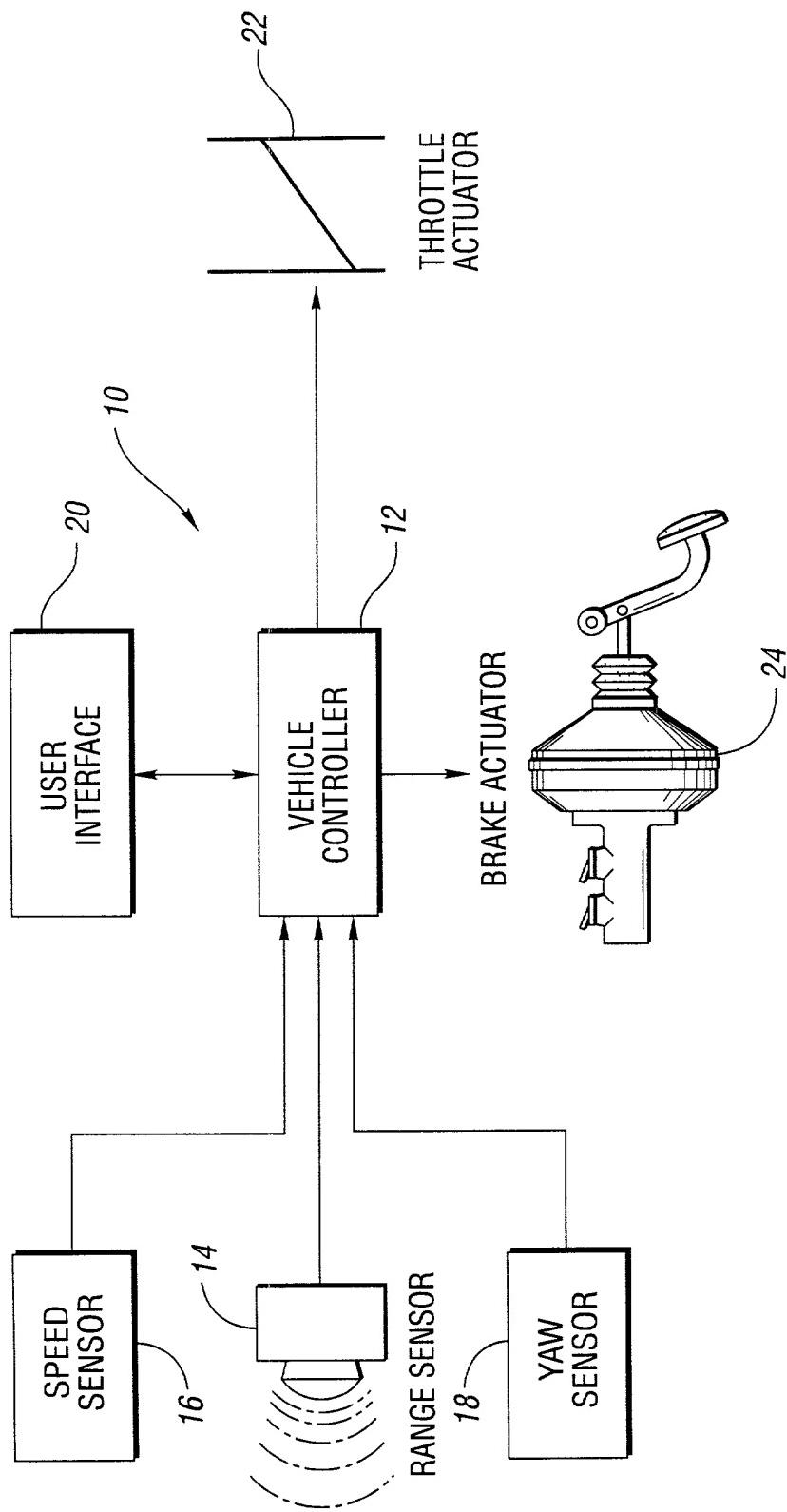
4                $\text{MAXDECEL} = 0.2 + 160 / (\text{VEHSPD} + 40)^2,$

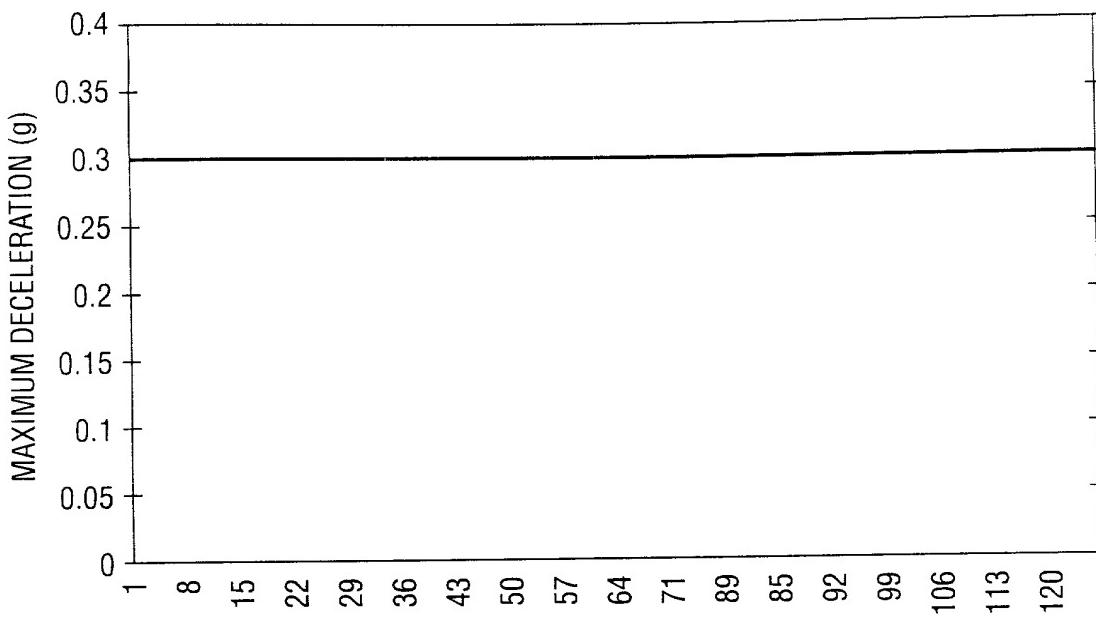
5 where MAXDECEL is the maximum allowed vehicle  
6 deceleration, and VEHSPD is the vehicle speed.

Abstract Of The Disclosure

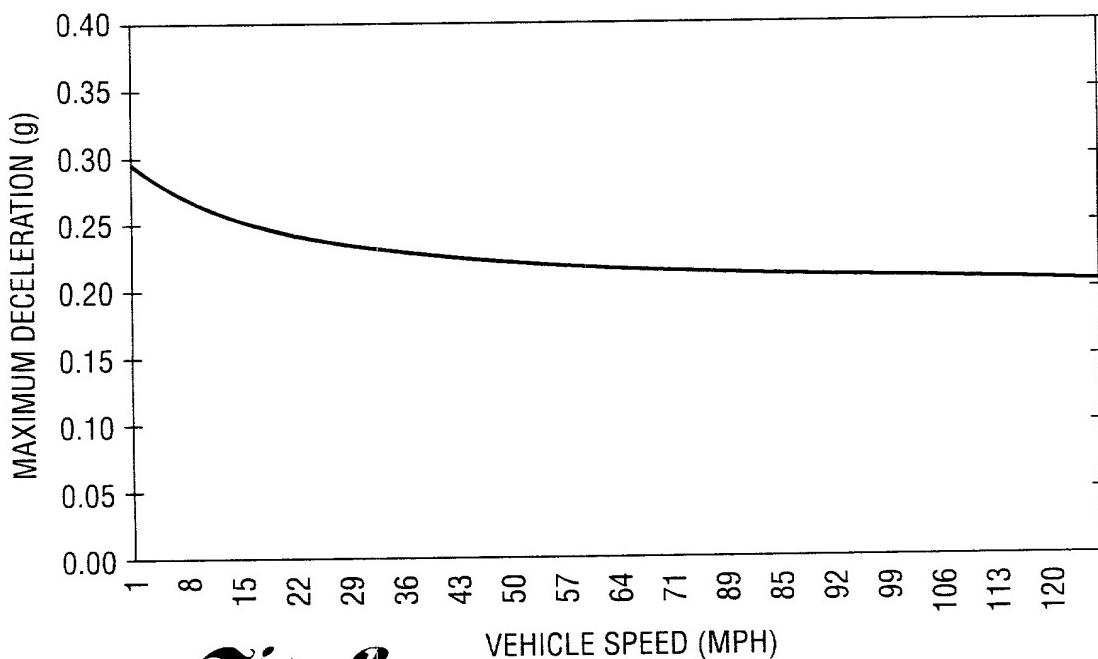
In an adaptive speed control system for a vehicle, a method and system for controlling vehicle deceleration are provided. The method includes  
5 determining a speed of the vehicle, and setting a maximum allowed vehicle deceleration based on the vehicle speed determined. The system includes a receiver capable of receiving an input signal indicative of a speed of the vehicle, and a controller  
10 capable of setting a maximum allowed vehicle deceleration based on the vehicle speed.

*Dwg. I*



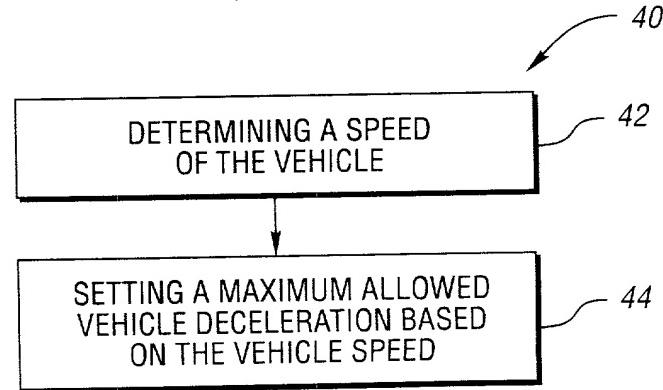


*Fig. 2*



*Fig. 3*

*Fig. 4*



**DECLARATION AND POWER OF ATTORNEY - ORIGINAL APPLICATION****Attorney's Docket No.  
199-1506**

As a below named inventor, I hereby declare:  
My residence, post office address and citizenship are as stated below next to my name;

I verily believe I am the original, first and sole inventor or an original, first and joint inventor of the subject matter that is claimed and for which a patent is sought on the invention entitled

**METHOD AND SYSTEM FOR CONTROLLING VEHICLE DECELERATION IN AN ADAPTIVE SPEED CONTROL SYSTEM BASED ON VEHICLE SPEED**

the specification of which is attached hereto.

I have reviewed and understand the contents of the specification identified above, including the claims.

I acknowledge my duty to disclose information of which I am aware that is material to the examination of this application in accordance with Section 1.56(a), Title 37 of the Code of Federal Regulations; and

as to application for patents or inventor's certificate on the invention filed in any country foreign to the United States of America, prior to this application by me or my legal representatives or assigns,

- no such applications have been filed, or  
 such applications have been filed as follows:

COUNTRY	APPLICATION NO.	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

(Application Number) (Filing Date) (Status - patented, pending, abandoned)

(Application Number) (Filing Date) (Status - patented, pending, abandoned)

**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the United States Patent and Trademark Office connected therewith and to act on my behalf before the competent International Authorities in connection with any and all international applications filed by me.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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